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Grain security in China

Current challenges and outlook for 2022 and beyond

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Executive summary

This study was carried out by the Sino-German Agricultural Centre (DCZ), a platform jointly financed by the German Federal Ministry of Food and Agriculture (BMEL) and the Chinese Ministry for Agriculture and Rural Affairs (MARA).

The study's objectives are to review the grain security situation in China in 2022, to analyze key domestic and external challenges, to discuss the various measures taken by China to overcome these challenges, to assess the implications of these measures for global food security, to provide an outlook on grain security in 2022 and beyond, and to make recommendations to Chinese and international stakeholders on coordinating grain security policies to reduce the negative impact of the various challenges of the global food crisis which is stemmed from the Ukraine conflict, Covid-19, and climate-induced weather disasters.

For this study, relevant Chinese statistical yearbooks, peer-reviewed academic journal articles, news reports, policy documents, and initiatives in English and Chinese were reviewed.

Key findings include:

- So far, 2022 has been a challenging year for Chinese grain security in multiple fronts.
- The Chinese leadership is strongly committed to grain security and self-sufficiency.
- The Chinese annual Document No. 1 states maintaining 120 million ha of cropland and 650 million tons of grain production as the red line.
- Chinese grain production remained constant, while grain imports increased rapidly.
- Chinese grain security suffers from chronic problems such as soil contamination, water scarcity and rural population decline.
- In 2022, Covid-19-related restrictions and the increasing frequency of climate-induced weather disasters have been new domestic challenges to grain security.
- The conflict in Ukraine, agricultural trade disruptions, currency fluctuations, and weather disasters in major food-producing countries are

the main external challenges to Chinese grain security.

- Grain stockpiling, diversification of imports, easing of GMO regulations and certifications, soil conservation, and prevention of food waste and loss are listed as major measures to ensure the grain security.
- International stakeholders are recommended to coordinate grain and agricultural trade policies and engage China in FAO and World Food Program on global food policies.
- Chinese stakeholders are recommended to promote healthy agricultural trade, advance agricultural digitalization and mechanization, invest in physical agricultural infrastructure, climate change preparedness, protect and rehabilitate soils, prevent food waste and loss, and adjust diets to meet grain security challenges.

1. Introduction

So far, 2022 has been a challenging year for Chinese grain security in multiple fronts. In the wheat- and corn-producing regions in the Northeast, the summer harvest has been impaired by heavy rainfalls that had occurred in autumn 2021. In central and southern China, extreme summer heat waves and droughts in 2022 have endangered the fall harvest. The ongoing Ukraine conflict has exacerbated the shortages in the world food and commodity market (Wong, 2022) and led to inflationary pressures that China cannot escape. China's strict lockdown policy in 2022 to combat various Covid-19 outbreaks in several provinces has disrupted agriculture production and supply chains. All these new developments complicate China's grain security, which is already plagued with persistent problems such as lack of efficiency, lower per capita land and water resources, soil contamination, and other chronic issues.

Against this backdrop, the Chinese government increased its emphasis on food and grain security, numerous policy measures have linked food security to national security. In a recent politburo meeting, President Xi reiterated his dictum "Chinese people should hold their rice bowls firmly in their own hands" which reflected the dire need to be self-sufficient in grains (Rouzi, 2022).

China is not only the largest producer and importer of agricultural products, but also a country where high stockpiles, certain trade restriction on agricultural products (e.g., fertilizers) and excessive Covid-19 measures affecting supply chains are of great importance to the world. Thus, Chinese policies on grain security would have a huge impact on global food security. Therefore, understanding the current situation and the actions taken by China will help various agriculture stakeholders around the world to better coordinate agricultural and food policies to address the global food crisis in 2022.

The purpose of this study is to outline the recent and current grain security situation in China and the major challenges to Chinese grain security domestically and externally, discuss the various measures taken by the Chinese government to address the situation, and how these measures would affect the global food crisis in 2022.

The study will also discuss the effectiveness of China's measures and provide recommendations and suggestions for relevant stakeholders in China on possible improvements. Meanwhile, suggestions will be made to external stakeholders on how to coordinate agricultural policies with China to mitigate the impact of the global food crisis.

2. Recent and current production and plantation situation of major grain crops in China

It is well known that China feeds 20% of the world's population with only 7% of the global arable land (Rouzi, 2022 & Veeck et al., 2020), in contrast, the US is home 16.5% of the global arable land and 4.3% of the world's population (Veeck et al., 2020). Due to its past experiences with famines, ensuring high grain production and a high degree of self-sufficiency has been a goal of China for a long time (Wang et al., 2022).

Although China had achieved its self-imposed goal of 95% self-sufficiency in the staple food grains by 2020, it still relies on heavy soybean and corn imports (Veeck & Pannell, 2021). Declining agricultural land, rapid urbanization, rising consumption of meat and dairy products, low agricultural productivity and growing dependence on imports make this objective increasingly untenable. Document No. 1, issued annually by China's state council as a guide to agricultural policy, sets a grain production target of 650 million tons as a red line (Figure 1). In 2021, grain production was above this threshold at 682 million tons. Despite the increases in production levels, China still needs more, due to ever increasing consumption and unforeseen events. The Chinese Academy of Social Sciences' 2020 Rural Development Institute report projected that "there is likely to be a grain shortfall of about 130 million tons, including about 25 million tons of staple food grain" by the end of 2025 (Greenwood, 2022).

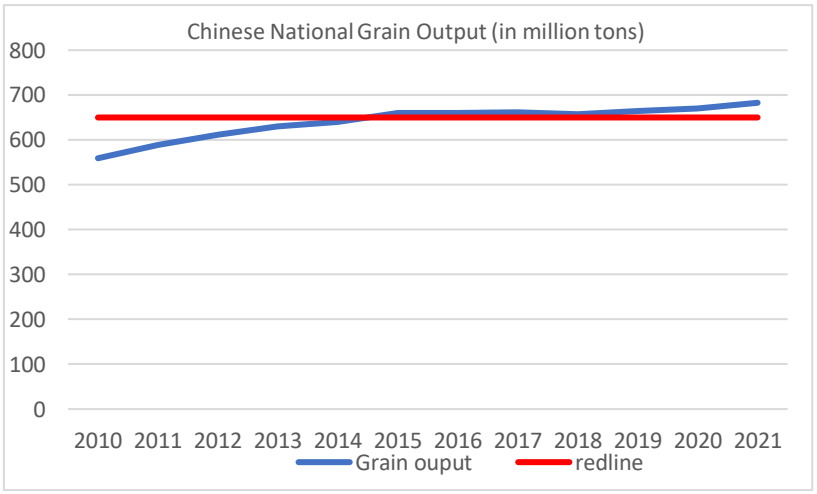

Figure 1: Chinese national grain output, 2010-2021 (NBS, 2021)

This profound projection alarms policy makers, who must find solutions to offset the deficit. Rising geopolitical tensions and emerging calls for deglobalization and decoupling in some countries have only increased the Chinese desire for food security and self-sufficiency (Kuhn et al., 2022).

2.1 Recent trend of production, imports, and cost-benefit analysis of major grains

Document No. 1 repeatedly states that the total area under food crops in China should be kept above 120 million ha (Figure 2), although it has been below 120 million ha since 2017. Rapid urbanization, growth of non-food cash crops, and soil pollution are believed to be the main causes of this decline. However, Chinese government has been complementing this decline by improving the productivity of existing farmlands by investing in agri-machinery, digital technology and better irrigation and fertilization methods. The 2022 Document No. 1 also emphasizes the strict implementation of the ban on conversion of arable land to non-agricultural uses, such as housing or urban development (State Council, 2022 & Rouzi, 2022). In addition to 650 million tons of grain production, China's 14th Five-year Plan (FYP) for 2021 to 2025 also sets 89 million tons of annual meat production which needs matching feed grains (Reidy, 2022).

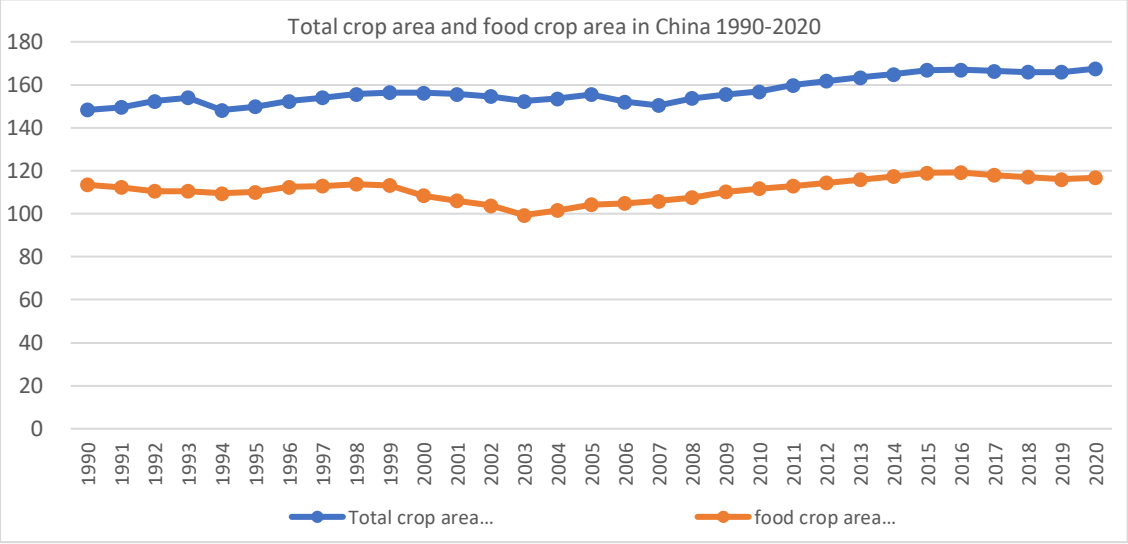

Figure 2: Total crop area and food crop area, 1990-2020 (NBS, 2020)

From 2010 to 2021, Chinese national production of five major grains slightly increased (Figure 3): corn production grew from 211 million to 272 million tons, whereas rice and wheat production remained stable with only little increase. By 2021, China had produced 212.8 million tons of rice and 136.9 million tons of wheat which made it self-sufficient regarding these two critical food grain crops. However, soybean production has remained minimal compared to

consumption, because many areas with soybean plantation were switched to plant corn and the gap in soybean production were filled with cheap imports from Brazil, the US, and elsewhere which coincided with WTO accession agreements on agriculture.

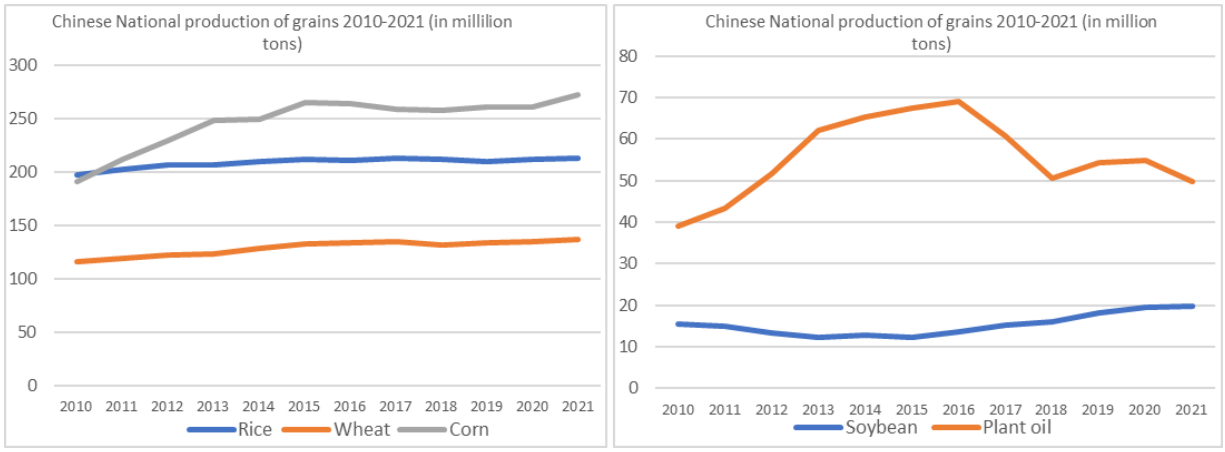

Figure 3: Chinese National production of major grains, 2010-2021 (NBS,2021)

In 2021, China's agricultural imports totaled USD 219.8 billion, an increase of 28.6% from 2020, while exports are only USD 84.3 billion, an increase of only 10.9% from 2020. Since 2007, Chinese agricultural imports have consistently far exceeded exports (Figure 4). Covid-19-related shortages, the implementation of the US-China Phase 1 trade agreement, and large-scale weather-related disasters in China's food producing regions have accelerated Chinese agricultural imports from various partners, of which Brazil was the largest source of agricultural imports at USD 41 billion and US was second at USD 35.6 billion in 2021 (USDA, 2022). EU agricultural exports to China amounted to EUR 17.6 billion in 2020 (EU Commission, 2022). Latin America, Southeast Asia, Russia, and Australia are also major suppliers of agricultural products to China. The recently enacted Regional Comprehensive Economic Partnership (RCEP), a trade pact that includes China and 14 other Asia-Pacific countries (Japan, ASEAN, Australia etc.), could provide China with new opportunities to diversify and regionalize its agricultural trade (CGTN, 2022).

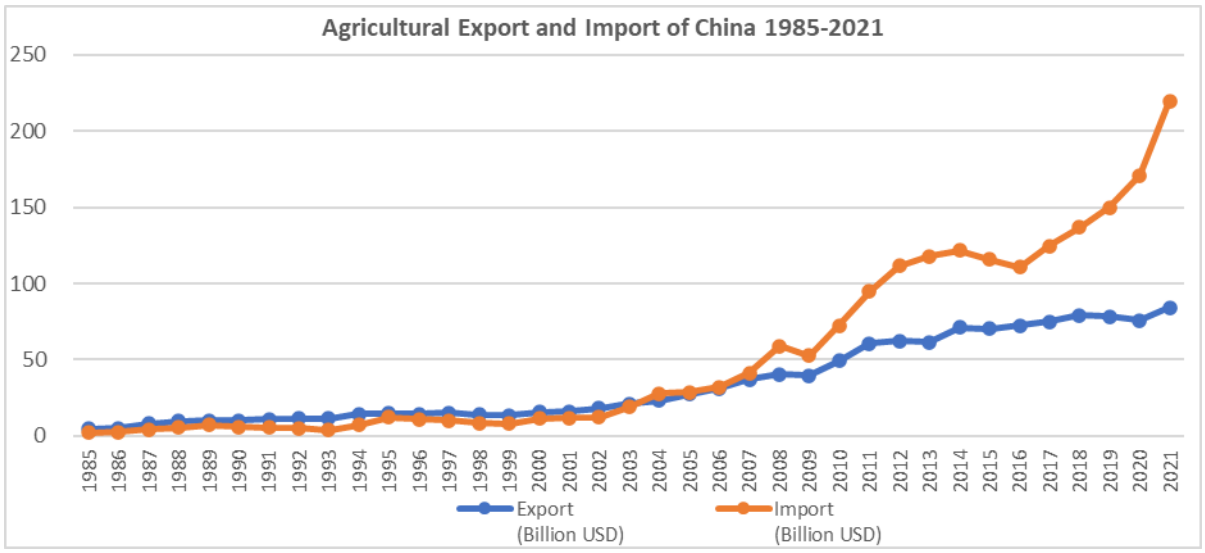

Figure 4: Agricultural export and import of China, 1985-2021 (NBS, 2022)

With the exception of vegetable oil, most Chinese grain imports have risen steadily since 2010, with wheat and corn in particular seeing dramatic increases from 2019, which could be attributed to Covid-19-related stockpiling and the recovery of the pork sector from the African swine flu outbreak. Chinese wheat imports increased from 1.2 million tons in 2010 to 9.7 million tons in 2021. Corn imports jumped from 1.2 million tons in 2010 to 28.3 million ton in 2021 (Figure 5), which is the most significant development. On the other hand, soybean imports increased with some fluctuation from 54.8 million tons in 2010 to 96.6 million ton in 2021, making the country even more dependent on imports. Even rice imports increased from less than a million tons in 2010 to 5 million tons in 2021. In 2021, China has imported USD 27.2 billion and USD 14.1 billion worth of soybeans from Brazil and US respectively, which is the largest single import of agricultural products (Reuters, 2022). Current trajectory indicates that Chinese demand for grain imports will not abate in the coming years, which could present opportunities and challenges for global players dealing with the global food crisis stemmed from the conflict in Ukraine. China's pursuit of grain self-sufficiency and dual circulation strategy pose additional challenges for agricultural trade. Niu argues that China still needs external markets to achieve its grain security goals (Niu et al., 2022). Growing geopolitical tensions and China's dependence on imports, as well as potentially world devolving into trading blocks, would add additional complexities (Kuhn et al., 2022 & Greenwood, 2022) and possibly disrupt agricultural trade patterns in years to come.

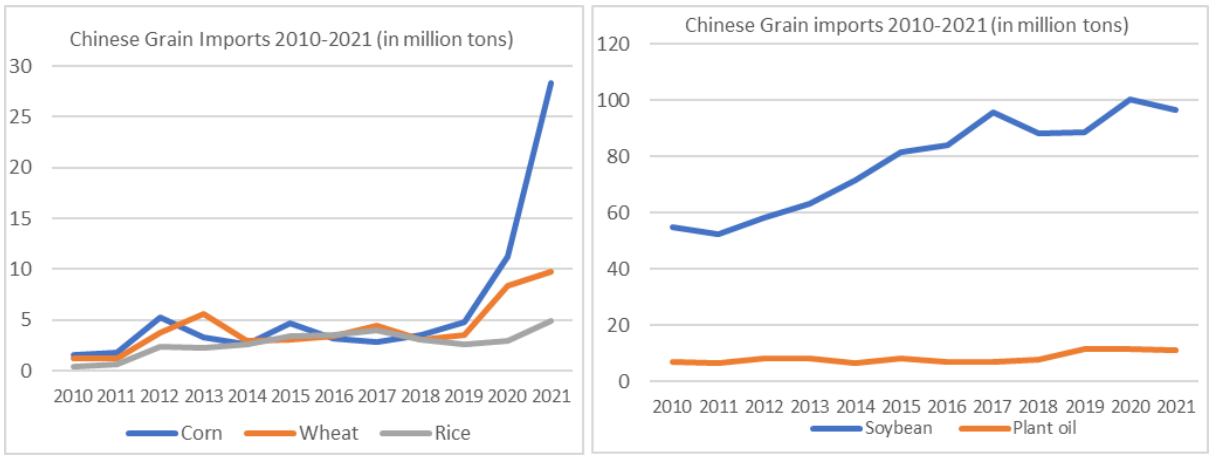

Figure 5: Chinese imports of major grains, 2010-2021 (NBS, 2021)

2.2. Grain production and imports in the first half of 2022

As announced by the National Bureau of Statistics (NBS) on 14 July 2022 (Chinese Gov, 2022), China's summer grain harvest reached a record level of 147.4 million tons, a year-to-year increase of 1.4 million tons which was considered a good basis to achieve an annual harvest of 650 million tons. Total summer planted area was 25.5 million ha, an increase of over 90,000 ha from the previous year, while wheat planted area increased by 50,800 ha (Global Times, 2022). However, the important autumn harvest, which accounts for most of the annual crop, faces serious challenges from summer heat waves and droughts in Central China, as well as other unforeseen weather events.

In the first half of 2022, China's total import of agri-food products reached USD 114.5 billion, up 6% from 2021, and grain import was USD 11.37 billion (CNFIA, 2022). China imported a record level of USD 17.5 billion worth of agri-food products from the US in the first half of 2022, including USD 5 billion worth of soybeans and USD 3 billion worth of corn, and total annual agri-food imports from the US are expected to exceed USD 40 billion in 2022 (Braun2, 2022). China is also buying more corn from Brazil to offset potential losses from the Ukraine conflict (Freitas & Cang, 2022).

2.3 Cost-profit analysis of Chinese grain production

As shown in Figure 6, total per Mu (1 ha = 15 mu) harvest values for wheat, corn, soybean, and rice in China has not changed significantly from 2015 to 2020. Meanwhile, production costs have increased steadily which resulted in net loss for all these crops, except for rice, which was

largely driven by rising labor and material costs. Yet, these crops were still able to generate net cash profit when unpaid family labor was discounted, and government subsidies were compensated. Soybeans were particularly unprofitable compared to other crops; therefore, China relies on cheaper imports for soybeans. The 2017 study by Gale et al. showed that total costs per metric ton of soybean in the three representative regions of Brazil, the US, and China amounted to USD 254, 313 and 655 respectively; the final price received for the crop in these three countries was USD 299, 341 and 540 respectively. The cost of Chinese soybeans was at least twice that of Brazil and the US (Gale et al., 2019), making them desirable Chinese import destinations.

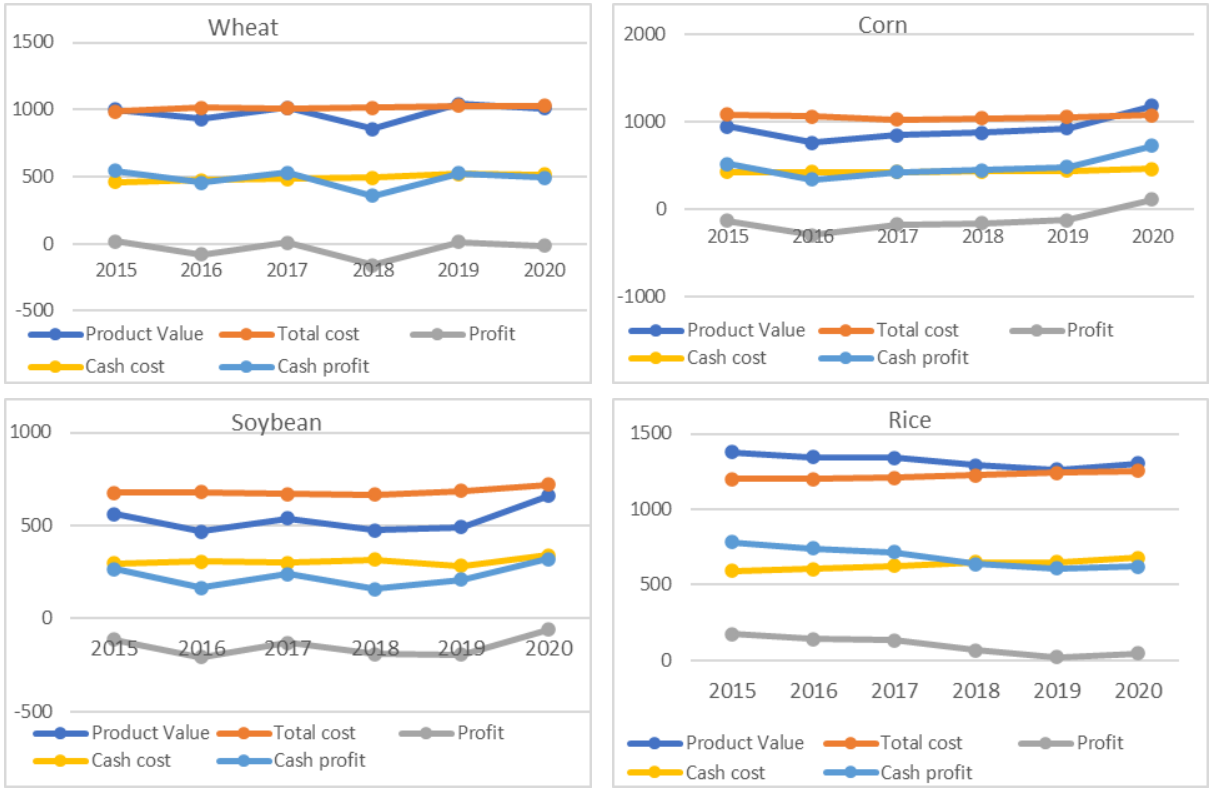

Figure 6: Cost-profit table for four major grains in China per Mu/RMB (NBS, 2021)

Compared to the US, all four major grains in China had consistently higher costs per kg in 2019 (Figure 7; Zhu et al., 2021). The cost differences for rice and wheat were smaller than corn and soybeans, for which China's cost of production per kg was more than twice that of the US. The cost per kg of soybeans in China was RMB 5.23, compared to RMB 2.41 in the US in 2019. Since Chinese feed grain production is not cost-efficient, China will continue to need agricultural trade to keep up with the demand, especially for the feed grains such as soybeans and corn.

Improving productivity and efficiency is a major dilemma facing Chinese agriculture producers given the current small per capita farm size, limited natural resources, and insufficient mechanization.

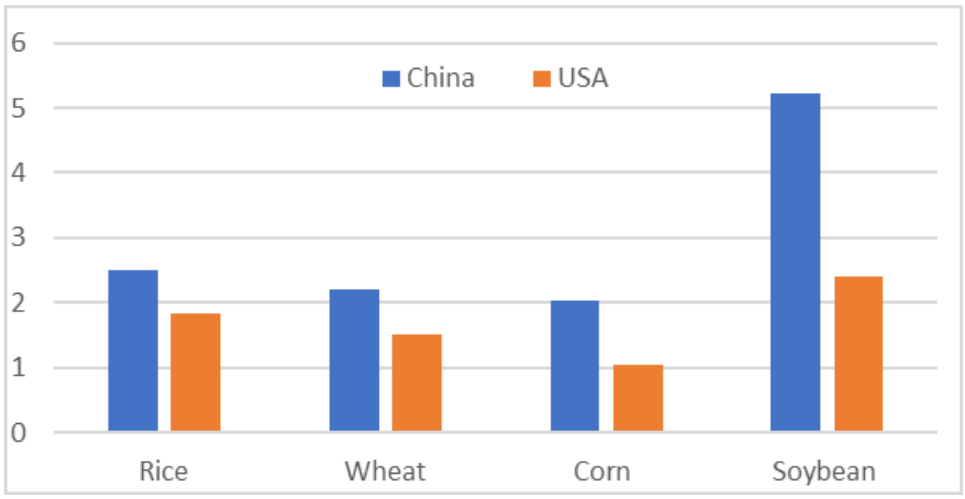

Figure 7: Cost per RMB/kg of four major grains, China, and the US, 2019 (Zhu et al., 2021)

3. Domestic challenges to the grain security in 2022

3.1 Persistent challenges

Chinese agriculture has long been plagued with multiple chronic challenges, due to resource scarcity and environmental pollution.

3.1.1 Changing consumption patterns

According to the latest food and nutrition report from the Chinese Academy of Agricultural Sciences (CAAS), since 1980, Chinese per capita grain consumption has increased from 337.8 kg/year to 582.5 kg/year in 2021, and per capita vegetable and fruit consumption increased similarly (Figure 8; CAAS, 2022). Meanwhile, per capita meat consumption increased fivefold from 12.0 kg/year in 1980 to 68.8 kg/year in 2021, which is even higher than the OECD average of 64.0 kg/year (Greenwood, 2022). Dairy consumption also increased from 1.2 kg/year in 1980 to 41.6 kg/year in 2021. The dramatic increase in meat and dairy consumption requires more feed grains, which can only be achieved through additional domestic production or imports, and both are coming under tremendous pressure. The changing consumption and dietary habits of the Chinese population are another challenge for grain security.

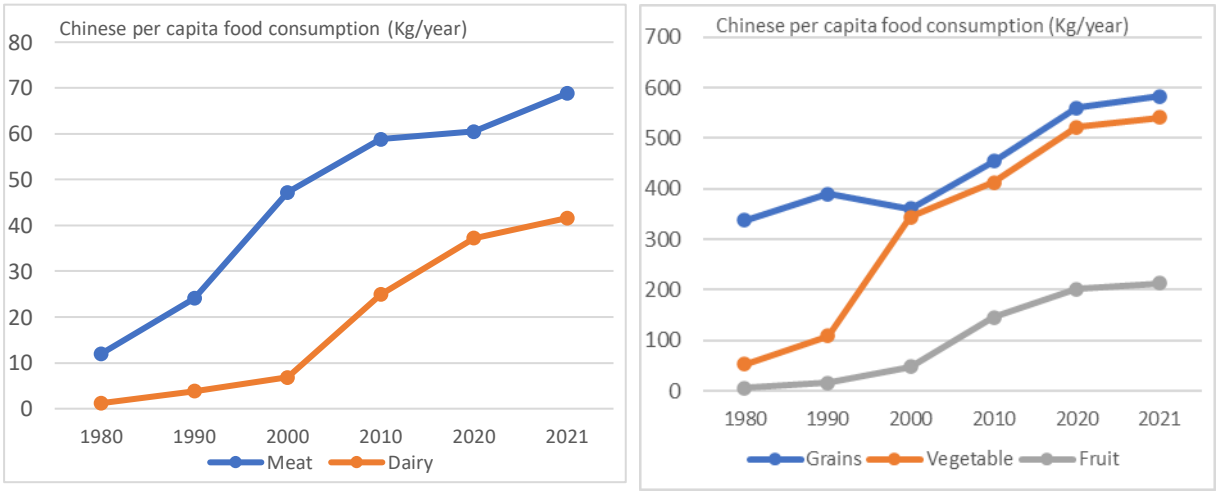

Figure 8: Chinese per capita food consumption by category, 1980-2021 (kg/year) (CAAS, 2022)

3.1.2 Water scarcity

China's per capita water resources are 2,079 m^3 compared to the global average of 6,225 m^3. They continue to increase and are expected to peak in 2030 (Ghose, 2014). The 2013 Chinese

National Water Survey showed that 60% of groundwater was polluted and 15.5% of groundwater was unsuitable for any use (Greenwood, 2022). Although the South-North Water Diversion Scheme, advanced irrigation techniques, and reservoir constructions at many rivers are used to secure water, finite and polluted water resources are still straining crop farming in China, while climate change induced droughts are likely to make the water situation only worse in the coming years.

3.1.3. Soil contamination and fertilizer use

Heavy metal contamination, acidification, and low organic content are major soil issues of concern in China. Several studies show that at least 19.4% of arable land is contaminated (Siebert, 2022 & Greenwood, 2022), which threatens stable grain production. Heavy metal contamination of soil resulted has led to the destruction of 10 million tons of grain and additional contamination of 12 million tons, according to a 2013 survey (Greenwood, 2022), so grain from contaminated soil also poses a health risk. A World Bank cross-national study on fertilizer use estimates that farmers in China used an average of 393.2 kg/ha of fertilizers for their arable land in 2018, while German farmers used 166.5 kg/ha and US farmers used 128.8 kg/ha (World Bank, 2022). Also, Chinese fertilizer use is much higher than the global average of 136.8 kg/ha. The excessive use of chemical fertilizers on Chinese farms is considered the main cause of soil contamination, poor water retention, and degrading soil quality (Veeck & Pannell, 2021).

3.2. Impact of weather-related events in 2021-2022 on Chinese grain security

The intensity and frequency of weather-related disasters in 2021 and 2022 presented additional risks to Chinese agriculture. In 2021, summer floods in Henan and heavy autumn rainfall in the Northeast destroyed or delayed harvest and winter plantation, which had lingering effects on 2022 summer harvest (Rouzi, 2022). On 19 August 2022, China issued its first national drought “yellow” alert to save crops from an unyielding heat wave. The situation is particularly acute along the Yangtze River, where some sections of the river in Sichuan and Chongqing have partly dried up and electricity supplies had to be curtailed (Reuters, 2022). With many cropland areas lost or damaged, experts fear that the autumn rice harvest in the region is in danger. So

far, the heat wave has affected 821,333 ha of cropland in six provinces and has put 830,000 people and 160,000 farm animals at risk (Schiefelbein, 2022). To mitigate the impact of the drought and stabilize the autumn harvest, as of 22 August 2022, the Ministry of Agriculture and Rural Affairs (MARA) has allocated RMB 300 million in special relief funds to help affected provinces in central and southern China (China Daily, 2022). The funds could be used for cloud seeding to generate artificial rain, water release from reservoirs upstream, and for early harvest of crops (Schiefelbein, 2022). Unforeseen typhoon or heavy rainfall in the southeast or other regions in coming months could still greatly damage the autumn harvest and winter plantation. All of these weather events add more uncertainty to the grain security situation in China.

3.3. Impact of Covid lockdowns on Chinese agriculture

Unlike most other countries who lifted most of the pandemic restrictions as of spring 2022, China has continued with its strict zero-Covid policy to tame the various outbreaks in 2022. The spring outbreak in Jilin and Shanghai in March 2022 is notable in its devastation to the agriculture sector (Sun, 2022). The strict quarantine and travel restriction measures have adversely affected agricultural activities in the major producing regions of the Northeast, particularly Jilin, Heilongjiang, and Liaoning, which together account for 20% of China's grain production. Jilin, the most affected province of the three, also has high-quality farmland and produces 10% of the national corn output (Ji, 2022). Strict quarantine and travel restrictions have prevented many farmers and migrant workers from returning to their fields for spring planting, causing shortages and supply chain disruptions of fertilizer, seeds, agricultural machinery services, and other necessary goods. The situation has improved as cases dwindled in Jilin; many farmers returned to the fields to resume spring planting (Ng, 2022). China's unrelenting approach to Covid-19 is expected to persist, further hampering agricultural activities in the affected regions and thus overall grain security.

4. External challenges in 2022

4.1. Conflict in Ukraine

The ongoing conflict between Ukraine and Russia, which began 24 February 2022, is not only an unspeakable humanitarian tragedy, but also exacerbates the global food security situation. Ukraine and Russia together constituted 18% of global output for barley, wheat, and maize (FAO, 2022) but a naval blockade in the Black Sea, ongoing fighting, and subsequent Western sanctions imposed on Russia cut off shipments of these critical grains to the world markets. Furthermore, the two countries produce 72% of sunflower oil, and Russia is the biggest supplier of Nitrogen (N), Potassium (K), and Phosphorous (P) fertilizers, which are critical ingredients to grain production (FAO, 2022). From 2018 to 2020, China has bought 16% of its wheat, 51% of its barley, 15% of its sunflower oil, and 8% of its fertilizers from Ukraine and Russia (Glauben et al., 2022). The Ukraine conflict also has spiked prices in global commodity, energy, and agricultural markets and contributed to food inflation with far reaching effect on all nations dealing with food insecurity (USDA, 2022). On 22 July 2022, Turkey and UN brokered a deal between Russia and Ukraine to allow agricultural exports clogged in the Black Sea ports to be shipped to world markets (Glauber & Laborde, 2022), however, Russian commitment to honor the agreement is yet to be seen. The Ukraine conflict has forced China to diversify its import sources and find other alternatives to substitute corn imports lost to the conflict.

4.2. International agricultural trade restrictions and disruptions

In addition to agricultural trade disruptions from the conflict in Ukraine, China has been dealing with ongoing trade disputes with the US, Australia, and Canada since 2018, including on agriculture. With the US-China Phase 1 trade deal in 2020, agricultural trade resumed between the two countries, but uncertainties from geopolitical tensions remain. Furthermore, to control inflation and secure domestic supply of grains, several countries are setting up trade barriers which range from decreasing export quota to outright export ban of certain food products. Since June 2021, Russia imposed taxes on grain exports to control domestic food prices. Argentina, Algeria, Egypt, Indonesia, Kazakhstan, Turkey, Hungary, and India have also imposed restrictions on food exports. India's wheat export ban, which started in May 2022, is the most significant by a major food exporter (Valantin, 2022). As of 9 September 2022, India, the largest

rice exporter, implemented the export restriction and 20% export tax on rice, which could hit Asian countries hard (Jacob, 2022). Although Brazil and other countries in South America offer competitive prices for grain crops, soybean plantation decreases from the extended drought in Brazil this year and war in Ukraine limits Chinese options for import diversification. On a positive note, China lifted the wheat import restriction on Russia (Valantin, 2022) in February 2022, which might supplement some loss of wheat from the Ukraine conflict. Covid-19-related port congestions and a strict Covid-19 testing of imported frozen food and animal products at Chinese customs are also creating supply backlogs in the various entry points. Although the most advanced economies have not imposed any trade restrictions on agriculture so far, shifting geo-political tensions still loom large on the reliability of global agriculture trade.

4.3. Currency fluctuation and international monetary policy

The US Federal Reserve has been tightening its monetary policy through increasing the benchmark interest rate several times this year starting in May and reducing purchases of financial assets in an effort to curb rampant inflation in the US (He, 2022). This led to RMB depreciating against USD. Since March 2022, the USD-RMB exchange rate has been increasing from 6.36 to 7.17 RMB/USD (as of 12 October 2022; Yung, 2022). The US is one of the largest sources of Chinese agriculture imports and USD is the most used currency in international agricultural trade. The continued deprecation of RMB against USD will increase the cost of agricultural imports from the US and other regions which use USD for international trade. It is believed that corn, soybean, and wheat imports will suffer the most from price increases. Potential price hikes resulting from currency fluctuation in these crops would contribute to Chinese domestic food inflation. On the other hand, the EUR-RMB exchange rate increase is insignificant in the same period, so that some agricultural producers in Europe could benefit from this volatility to some extent.

4.4. Weather events in the food producing regions of the world

As in China, the grain producing regions in the US, Brazil, Argentina, Europe, and India have also been experiencing heat waves and droughts this year. The midwestern US, which produces and exports a huge amount of corn and soybean, could lose a substantial amount of its harvest to the drought, with Iowa and Nebraska hit hardest. Against this background, some analysists

predict that US grain production could decline by 4% (Chipman & Veloso, 2022). It is also reported that the La-Nina-induced dry spell could reduce the grain output in Brazil and Argentina as well. The world's largest rice trader, India, cut its rice plantation by 8% in 2022 due to drought, having analysts worry that India could curb its rice exports similar to its wheat export ban (Good, 2022). Summer drought would also reduce crop output in Western Europe (Chipman & Veloso, 2022). These weather-related grain output decline would result in supply shortages and limit China's options to withstand the potential shocks.

5. Chinese measures to tackle grain security and their implications

5.1. Grain stockpiling

Due to supply chain disruptions from the Covid-19 lockdowns and the ongoing conflict in Ukraine, many countries rushed to secure their food resources by grain stockpiling (Ryan, 2022). According to the USDA estimates, China holds 50% of the wheat and 70% of the corn reserves. India has almost one tenth of global wheat stockpiles (Valantin, 2022). The US has 6% and 12% of global wheat and corn reserves, respectively. According to USDA's latest estimates, China will hold 65% of world's corn and 53% of world's wheat reserves by 2023 (Braun1, 2022). Compared to these countries, many countries in Asia and Africa have much less reserves, which makes them more vulnerable to food supply shocks. Since the outbreak of Covid-19 in 2020, China has steadily increased its grain imports from Europe as well as North and South America to ensure food security. Therefore, China is better prepared for food supply chain shocks and shortages. Some analysts have criticized China's grain stockpiles which, they argue, intensify the global food crisis. Braun (2022) finds these arguments ironic since China was obligated by the US-China Phase 1 Trade Agreement and other trade agreements to make more agricultural purchases. In China, it has been argued that feeding 1.4 billion people is in itself a major contribution to global food security.

5.2. Cultivate high-standard farmlands

According to 14th FYP, the high-standard farmland area should reach 71.1 million ha by 2025 (Reidy, 2022). The plan also states that strong restriction measures on land conversion of croplands into non-agricultural purposes should be placed and violators should be punished. It also calls for expansion of soybean planation in the Northeast and rapeseed cultivation along the Yangtze River (Rouzi, 2022). MARA minister Tang RENJIAN declared that China would improve and conserve Chinese domestic farmlands by 25% (Greenwood, 2022). As Greenwood noted, the 14th FYP also intends to upgrade its arable land through saline and alkali lands in northern China and acidic soil in southern China. Given the current heavy soil contamination of Chinese arable land due to the use of chemical fertilizers and pesticides, the positive results of soil improvement and remediation efforts is far from guaranteed. The conflicting priorities of

further urbanization and rural revitalization in the 14th FYP make the expansion and cultivation of high-quality farmland hard to achieve. Crop rotation, intercropping, and agro-forestry would be other viable options to sustain the quality and production levels of farmlands.

5.3. Easing on GMO regulations and certifications

As grain security has become a top priority, Chinese policy makers are turning their attention to the seed sector to increase the production of crops, especially for feed crops like soybeans and corn. China's 14th FYP and "economic goals set to be achieved in 2035" named "biological breeding" as one of the eight forward-looking projects for the next five years (Rouzi, 2021). MARA minister Tang Renjian declared "seeds are the new 'semiconductor microchips' in agricultural technology" and shall be instrumental in securing grain output (Pandy, 2022). The establishment of the Nanfan Center for Seed and Animal Breeding, the so-called "Southern Silicon Valley" in Hainan province, aims to strengthen the seed sector development (Rouzi, 2021).

MARA estimates that China imports more than 80% of its soybeans. Yet, in the long run, China is determined to become self-sufficient in feed crops like soybeans and corn. To accelerate the seed sector development and provide a clear regulation and legal framework, the Chinese government passed a new seed law which has come into effect in March 2022 (Hansen, 2022). The Document No. 1 also stated that further IP protection of seeds should be ensured to boost innovation. Although GMOs have long been regarded as controversial in China, the recent relaxation of GMO regulations is also seen to boost seed sector development (Sim & Rennie, 2021). Results of the GM soybeans and corn pilot projects in China indicated a reduction in weeding costs by 50% and increased output by 12% (Donnellon, May 2022). In January 2022, MARA also approved trial rules for gene edited plants.

The Chinese seed market is estimated at around USD 21 billion, making it the second largest in the world, and there are more than 6,400 companies currently listed in the country (Hansen, 2022). Although acquisition of Swiss seed and pesticide company Syngenta in 2017 by state-owned chemical company ChemChina was a milestone in the Chinese seed sector development, Chinese companies still lag behind global heavyweights like Monsanto-BAYER, Dow, BASF, and DuPont in GMO and seed innovation (Wong, 2022).

5.4. Black soil and other soil protection measures

To prevent further deterioration of black soil, which produces most of Chinese staple grains such as wheat, corn and soybeans, China has passed the black soil protection law, which has come into effect in August 2022 (CGTN, 2022B). The law intends to protect 6.67 million ha of black soil in the northeastern provinces during the period of the 14th FYP. The upcoming third national soil survey, to be completed by 2025, would provide farmers and policy makers with a comprehensive picture of the soil situation in China (Chen et al., 2022). Soil conservation measures not only enhance grain security, but also contribute to China's commitment to become carbon neutral by 2060 (Meyers, 2020), with carbon sequestration through soil improvement playing a critical role in offsetting carbon emission from other sectors.

5.5. Food loss and waste prevention measures

More than 35 million tons of food, around 6% of Chinese total food production, are lost or wasted annually in China – food that could feed 30 to 50 million people, according to some estimates (Marchisio, 2020). Several efforts are carried out to reduce food loss and waste, exemplified by the "Clean Plate" campaign and anti-food loss and waste law, which was passed in 2021. Under this law, excessive food waste in restaurants is prohibited and those who violate it are subjected to an economy fee or a fine of up to RMB 10,000 for an individual and RMB 50,000 for a restaurant (Wong, 2022B). Immediately after the law was passed, binge-eating shows and live streams that promoted food waste and extravaganza were removed from Chinese video-sharing platforms (Wong, 2022B). More than a year after China's Food Loss and Waste Law was passed, the National Development and Reform Commission (NDRC) announced a series of measures to ensure enforcement in 2022. Furthermore, standards for evaluation and inspection of food loss and waste will be revised and a statistical and monitoring system for grain loss and waste established (Global Times, 2022), which observer welcome as a positive step toward sustainability and grain security.

5.6. Agricultural trade

With accession to the WTO in 2001, China has gradually opened its agriculture market to the outside world. However, Chinese agriculture producers could not keep up with the cost gap with major exporters like the US, Brazil, Canada, and Australia (Wang, 2022), which led to huge

imports from these countries, especially of feed crops, meat, and dairy products. Due to geopolitical events, China has been trying to diversify its agricultural trade away from the aforementioned countries to countries in the Belt and Road and RCEP (Regional Comprehensive Economic Partnership), but with limited success. Diversification efforts are likely to be affected by the conflict in Ukraine and the decline in production due to extreme weather events in major food producing regions in the near future.

Although Chinese authorities strongly promote grain self-sufficiency, it could come with heavy environmental and financial costs, which can be alleviated by agricultural trade. According to Huang et al., in 2015, agricultural trade with the rest of the world has saved 9.5×10^{10} m^3 of virtual water and 1.52 1×0^{7} ha of arable land for the globe, and it would save 1.344×1011 m^3 of virtual water and 1.437×10^{7} ha of arable land for the globe by 2050 (Huang et al., 2022). Limited land and water resources severely strain China's ability to produce the agricultural products cost-effectively and resource-efficiently. Therefore, Huang argues, importing these vital products from overseas would not only be cost-effective, but also environmentally friendly in the long run.

6. Outlook for 2022/2023 and beyond

6.1 Near term

USDA estimates that in the near term, China's wheat production could decrease by 1.95 million tons for 2022/2023 marketing year to 135 million tons, wheat area for MY 2022/23 is estimated at 23.4 million ha, down 170,000 ha (USDA, 2022). China's MY2022/23 feed and residual use is forecasted to increase 4.5 million tons from MY2021/22, on recovering demand for hog feed as hog production becomes more profitable (USDA, 2022). Industry experts at the 2022 China Agricultural Outlook Conference estimated that total the feed consumption for 2022 would increase by 2.9% year-on-year to 301.6 million tons (Donley, 2022). Due to the summer drought and other factors, for 2022/23, China is forecasted to import 9.5 million tons of wheat and 6 million tons of rice, according to the latest USDA projections which is record amount to date (Gro Intelligence, 2022). Most of these projections shows a slight decline in domestic production and large import increases of staple grains for China in 2022/2023.

6.2. Long term

Huang projects that by 2030, Chinese grain production would decline by 15.29 million tons in which output for wheat would be down by 6.13 million tons (Huang et al., 2022) under the base scenario.

7. Recommendations

7.1 International stakeholders

1. Coordinating grain policies with China by active consultation and coordination of grain policy measures such as stockpiling, lifting export restrictions, and other relevant issues would greatly improve global food security.
2. Promoting healthy agricultural trade with minimal restrictions and facilitating the exports of fertilizers and other agricultural chemicals from China to the rest of the world to offset losses from the Ukraine conflict can mitigate global food security challenges by providing needed inputs.
3. More engagement with China on global food governance at international organizations: China has been an active participant of FAO and World Food Program and has also its own initiative called “South-South Cooperation” which offers aid and training to the developing countries in the field of agriculture. Increased Chinese resource commitment to these organizations and other initiatives to offer valuable technology and training for countries in Asia and Africa would greatly contribute to lessen the impact of current food crisis on the developing countries.

7.2 Chinese stakeholders

1. Agricultural trade: fair and reciprocal access to the Chinese market under the WTO would improve agricultural trade and food security in China by balancing the needs of Chinese consumers and various trading partners.
2. Mechanization of the grain sector: Chinese corn and soybean production is not cost-efficient. Therefore, further mechanization would reduce costs and make grain production more competitive.
3. Investment in physical agricultural infrastructure, like water-efficient irrigation systems, would better prepare crop land for climate-induced water shortages and other unforeseen events.
4. Digitalization would increase grain productivity by using real-time data for farming decisions and improve the efficiency of post-harvest logistics, distribution, and sales.

5. Climate and unforeseen weather event preparedness: To mitigate climate-induced weather events' impact on grain security, a better disaster early warning system should be established to prepare farmers for different scenarios, and disaster insurance schemes should be promoted to reduce the financial loss of farmers in the event of natural disaster.
6. Promotion of soil protection and sustainable farming practices
7. Seeds and biotechnology: it is recommended that the People's Republic of China signs the 1991 UPOV convention and fully implement the standard for plant variety protection to accelerate the seed sector development. Further protection of IP and more market access to foreign companies would also boost the cooperation and innovation in the seed sector. Newly established Nanfan Seed Research Center which is dubbed as "Silicon Valley of seeds" could serve as innovation basis for seed and biotechnology in China and beyond.
8. Preventing food waste and loss: wide-scale enforcement of national law against food waste and loss would save additional food resources and promote awareness of sustainable food consumption.
9. Dietary changes: promoting healthy diets that discourage heavy meat consumption and advocate traditional Chinese diets and alternative proteins would alleviate the pressure to produce and import more and more grain to feed more and more animals for meat production.

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